ON THE ORIGIN OF STEREOSPECIFICITY IN BIOLOGICAL SYSTEMS

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" The harmonious cooperation of all beings arose not from the orders of a superior authority external to themselves, but from the fact that they were all part of a hierarchy of wholes forming a cosmic pattern, and what they obeyed was the internal dictates of their own natures."

Chang Tzu - 3rd century B.C.

Chemical stereospecificity is so inextricably linked to life as we know it that it seems inescapable that their origins were interlocked. I wish to propose a hypothesis for the existence of stereospecificity in biological systems based upon intrinsic chemical properties of polynucleotide chains.

The fact of the synthesis of organic molecules, including nucleotides, on the primitive earth rests on a secure experimental basis [1]. The abiotic formation of oligonucleotides from such precursors has been demonstrated [2]. It is a chemical property of nucleotide chains that the component bases possess a specific affinity for other bases of suitably complementary structure. In this way the production of nucleotide chains complementary to an original template and eventual replication of the template itself is explained [3]. However, complementary chain formation depends upon a second factor in addition to complementary base affinities. That is the ability of the complementary bases which have become associated with the original nucleotide chain to become linked together. The chemical constitution and spatial arrangements within the individual nucleotide are obviously critical in this connection, but equally critical are their 3-dimensional relationships to one another along the original template chain with which they have become associated. That is, they must be in close, continuous array if multiple units are to be linked together. The geographical relationship to one another of nucleotides associated with a pre-existing nucleotide chain in turn depends upon the conformation of the template chain. A chain in random conformation could not lead to a close sequential orientation of associated bases from which a complementary chain could be constructed. On the other hand, a template chain in a helical conformation possesses precisely this property [4]. Therefore, a nucleotide chain capable of assuming a helical conformation can best serve as an effective template for complementary chain formation, and thus for its own eventual replication. In turn, only a chain composed of members of the same stereo configuration can form a helix. Thus all D- or all L-chains or segments of chains can replicate best. In a pool of nucleotides of appropriate structure for chain formation, but composed of enantiomorphic mixtures of each type, the original production by chance processes of chains or segments of chains comprised of components of the same stereo configuration would occur relatively rarely. Yet since it is precisely these members of the population which possess the requisite chemical and physical properties for replication, their type would come to predominate. Further chance additions to such chains would then become established when they were of the same configuration as the chain to which they became linked; that is, in 50% of the

trials. It is not essential to the argument that only the conformation arising from chains of units of identical configuration be capable of forming complementary chains, but only that it serve best. In genetic terms the stereoisomerism is the genotype and the conformation of the nucleotide chain the consequent phenotype upon which selection for reproductive potential at this level operates.

This model has as its corollary that self-replicating systems preceded permanently established metabolizing systems. Since it has been easier to produce polyamino acid chains than polynucleotide chains abiotically, it has been argued that the formation of the former preceded that of the latter in prebiotic evolution. However, since polynucleotide formation is autocatalytic the original unfavorable rates of their formation vis-à-vis polyamino acids would soon be overcome. As in all such proposals it requires that somehow nucleic acid chains led to the formation of polyamino acid chains by as yet undefined processes. Whatever these processes may have been, it would be expected that chains of nucleotides of identical configuration would tend to give rise to chains of amino acids of identical configuration [5]. Insofar as these had catalytic capabilities, they themselves would catabolize or biosynthesize stereospecifically. It is not argued that only all D- or all L-polyamino acid chains need have catalytic capability. However, since, as developed above, the information in all D- or all L-nucleotide chains can best survive the life-time of the latter, they compete best in the processes of evolution and selection.

To complete the argument for the existence of only D-sugar chains of nucleic acids in living systems on the earth, it is only necessary to suppose that from among all the all D- and all L-chains which may have formed on the prebiotic earth, the successful competitor in the race to become the progenitor of living organisms happened to be an all D-form.

A prediction from this model which is in principle testable is that in the abiotic formation of oligonucleotides from racemic mixtures of precursors in the presence of an optically homogeneous template, optically homogeneous products of a complementary sequence would be favored. Another is that of all the systems of life which are analogous to the terrestial and segregated from one another within the universe, half would be of the same configuration as terrestial life and half would be mirror images. The latter proposal is not novel with the present author [6].

References

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